Power Supply Efficiency:

What Have We Learned?

February 2004

Introduction

The Natural Resources Defense Council (NRDC), with funding from the U.S. Environmental Protection Agency (EPA), initiated a study of power supply energy efficiency in 2001. NRDC retained Ecos Consulting (Ecos) to conduct initial research into the number of power supplies in use, their basic applications and technologies, energy efficiency differences, and national energy savings opportunities. Ecos found that improvements in power supply efficiency could save more than 1% of all U.S. electricity use. This would not require the invention of better power supplies, but the expansion of market opportunities for the highly efficient technologies that already exist. Additionally, roughly 75% of the total energy savings opportunity is in products' active or operational mode, rather than in the standby or low power modes that have been the traditional focus of research and efficiency labeling programs for electronics.

This research helped catalyze new policy activity at EPA's ENERGY STAR® program and at the California Energy Commission, whose Public Interest Energy Research (PIER) program funded a two-year focused analysis of power supply energy savings opportunities. Three organizations are conducting that effort: the Electricity Innovation Institute (E2I) as prime contractor, Ecos as market and policy researcher, and EPRI-PEAC as technical researcher. The goals of this project include:

- Standardizing test procedures to measure power supply energy efficiency
- Collecting and disseminating a substantial volume of efficiency test data
- Developing improved estimates of the total number of power supplies in use and their total energy consumption
- Working closely with industry to improve the efficiency of existing power supply designs through information sharing and a design competition
- Recommending policy options to the State of California

This document summarizes key findings from 2003-2004, project objectives through mid-2005, and market opportunities for utilities and manufacturers.

Power Supply Fundamentals

Power supplies are the devices that convert incoming high voltage ac power from wall outlets into low voltage dc power needed by various electronic products. Power supplies can be internal to the product they are powering, as with televisions, or external, as with cellular and cordless phones. These external "adapters" are perhaps the most familiar type of power supply to consumers, and also represent the most obvious opportunity for energy savings. They can be replaced outright in existing devices, or more efficient ones can be specified when new devices are sold, without having to redesign the entire product.

The sheer reach of power supplies in the marketplace is remarkable. All ac-powered products utilizing integrated circuits, digital displays, electronic timers, transmitters, receivers, dc motors or lighting, speakers, soft touch switches, remote controls, keyboards, or rechargeable batteries are driven by power supplies. This includes virtually all consumer electronics and office equipment such as answering machines, fax machines, computers, monitors, camcorders, and stereo equipment. There are also numerous scientific, industrial, and military applications of power supplies in laboratory and medical diagnostic equipment, process controls, air traffic control centers, and data and telecommunications centers.

Ecos' most recent market research for PIER finds more than 3.1 billion power supplies in operation in the U.S. and about 10 billion in use worldwide in hundreds of types of electronic products. This is a substantial increase from the 2.5 billion U.S. units identified in the initial research for NRDC. The estimate of the fraction of total U.S. electricity use that passes through power supplies also increased from 6% to a range of 6 to 10%. This range of uncertainty reflects the reality that

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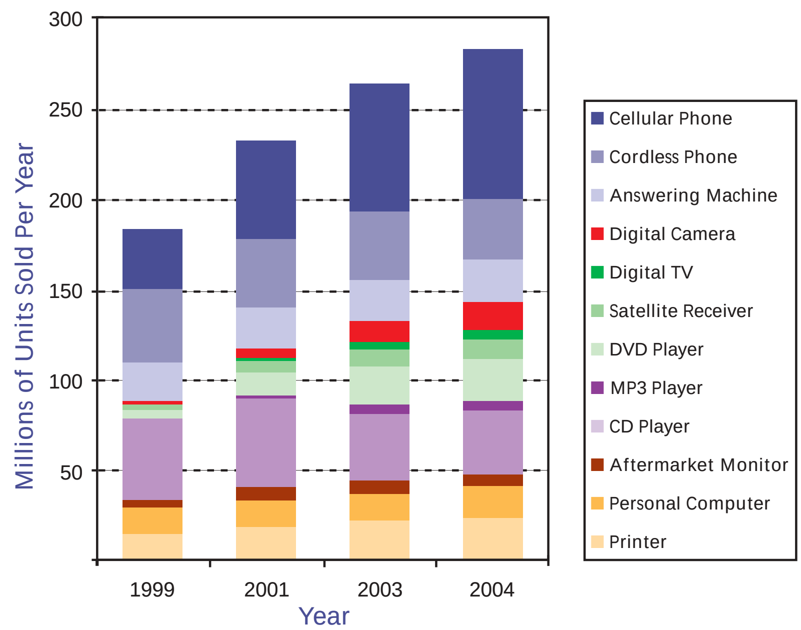


U.S. sales of these power supply-containing products are expected to rise 55% between 1999 and 2004. Source: Consumer Electronics Association

current data on product sales and number of products in use are much more complete than data on typical hours of use for products by operating mode.

Unfortunately, most current power supplies are only 30 to 60% efficient when operating, and consume 1 to 3 watts even with no product attached to them (no load). Improved designs are 70 to 90% efficient and consume less than 0.2 watts at no load. Approximately 1 to 2% of all U.S. electricity use could be saved cost-effectively by switching to these more efficient designs. This translates into approximately 30 to 60 billion kWh and a staggering $2.5 to $5 billion per year in energy costs.

For electric utilities and policymakers the message is simple. Electronic "plug loads" are rising as a share of residential and commercial electricity use. At the same time, steady improvements in lighting, appliance, HVAC, and water heating efficiency are narrowing future opportunities for energy savings in those traditional end uses. Electronics are the place where substantial new gains in efficiency can be made.

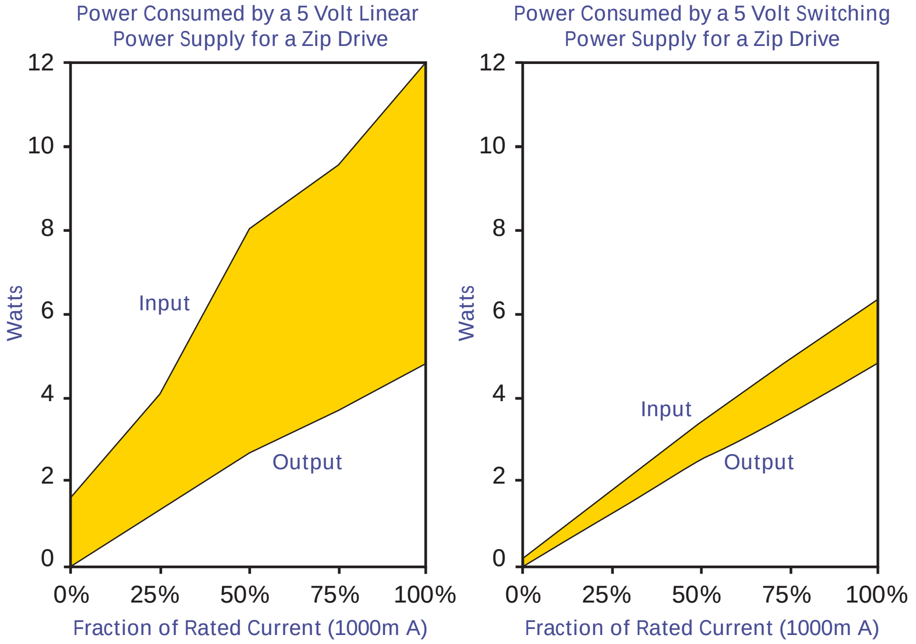
Fortunately, efficient power supplies offer key advantages to consumers beyond energy savings. Improving external power supply efficiency yields smaller and lighter designs that increase portability and convenience for consumers, reduce packaging and shipping costs for manufacturers, and take up less shelf space in retail stores (see photo). Improving internal power supply efficiency reduces the production of waste heat and the need for noisy cooling fans. For example, a highly efficient desktop computer power supply can reduce heat output by as much as 100 watts, while operating far more quietly and paying for its additional cost in a matter of months through lower energy bills.

Key Research and Policy Progress

Standardized Test Procedures

Simply defined, the operating efficiency of a power supply is its dc output power divided by its ac input power. Unfortunately, manufacturers employ a wide range of different procedures for measuring efficiency, making it difficult to fairly and accurately compare the efficiencies of different power supplies.

Ecos and EPRI-PEAC began development of standard test procedures in the summer of 2003, posting drafts of external and internal power supply test procedures on



The shaded areas represent the net power consumption of each power supply – the amount of ac power input that is converted to heat instead of becoming useful dc power output. Both units are designed to produce a similar amount of dc output power across a range of loading conditions. But at 100% load, the linear design draws nearly twice the ac power of the switching design (12 watts vs. 6.3 watts). At 0% load, it draws more than 8 times the ac power (1.7 watts vs. 0.2 watts).

www.efficientpowersupplies.org. The external procedure underwent multiple revisions between August 2003 and February 2004. It was presented at meetings of the European Code of Conduct process in Italy, meetings with key test laboratories and government agencies in China and South Korea, and a well-attended stakeholder workshop with industry in San Francisco. Nearly 800 power supply samples were tested according to the draft procedure by Ecos in the U.S., CEPREI in China, and by the Australian government. This final test procedure has emerged as the common technical foundation of planned labeling, standards, and procurement programs for efficient external power supplies in North and South America, Europe, Asia and Australia.

Draft internal power supply test procedures have been more challenging to standardize because they vary by application. However, EPRI-PEAC, Ecos, and NRDC worked closely with Intel to standardize a measurement approach for part-load conditions in PC power supplies. As a result, Intel's new PC Design Guide Specification (www.formfactors.org) includes aggressive targets for power supply efficiency across a range of load conditions, paving the way for future computer efficiency labeling and incentive programs to include consideration of active mode energy use.

International Design Competition

Power supplies for most applications have become a commodity, differentiated primarily by price instead of by performance, features or quality. While advanced power supply designs already exist, they face a stiff challenge competing against cheaper alternatives. Ecos, EPRI-PEAC, and E2I have proposed a design competition to coax the most energy-efficient designs from today's leading power supply manufacturers, and then encourage their widespread adoption in consumer products as a superior, cost-effective alternative to current power supply choices.

The Energy Commission and EPA's ENERGY STAR program are jointly sponsoring the design competition, which has also been endorsed by the Power Sources Manufacturers Association (PSMA). After its public announcement on February 23, 2004 at APEC (Applied Power Electronics Conference), the contest runs throughout the fall of 2004, with winners recognized in March 2005 at the next APEC.

Key elements include:

- a "market-ready" class to encourage finished designs whose total cost of ownership (purchase price plus operating cost) will be lower than conventional designs
- an "open" class to encourage the most efficient prototypes from industry and academia without cost constraints
- subclasses by wattage and power supply type, focusing on the market applications where energy savings potential is greatest
- a scoring process that encourages partnerships between power supply vendors and electronics product manufacturers to incorporate advanced power supplies into highly efficient finished products

In addition, project leaders hope to generate interest among utilities and government agencies in procuring products that incorporate the resulting designs. Complete contest details are available at www.efficientpowersupplies.org.

International Efficiency Policies

After analyzing the international test data on external power supplies, Ecos recommended efficiency levels that separately represent the top 25% of active mode efficiencies and no-load efficiencies tested to date. ENERGY STAR and China's Certification Center for Energy Conserving Products (CECP) incorporated these recommendations into draft efficiency labeling program specifications they announced at APEC on February 23, 2004 (www.energystar.gov/productdevelopment). These recommendations were partially adopted by the European Code of Conduct as well (http://energyefficiency.jrc.cec.eu.int/html/news_SBI.htm). The Energy Commission is considering somewhat similar levels for mandatory efficiency standards in California. Efficiency labeling programs and/or mandatory standards for power supplies are also under consideration by Australia's National Appliance and Equipment Energy Efficiency Committee, Brazil's Electrobras/Procel, Natural Resources Canada's Office of Energy Efficiency, and the U.S. Department of Energy.

Looking Ahead

Key opportunities for partnership and progress on power supply efficiency in 2004/2005 include:

For manufacturers: submit advanced designs to the design competition, test existing products according to the draft test procedure, provide the resulting data to ENERGY STAR, and post information about efficient new products and submit comments about the internal power supplies test procedure at www.efficientpowersupplies.org

For utilities: undertake field measurements to better understand the total energy use of plug loads in homes and offices, participate in government labeling and standards discussions, and procure winning products from the design competition

For government agencies: harmonize test procedures and efficiency specifications with activities already underway at the Energy Commission and ENERGY STAR, conduct additional country-specific power supply efficiency testing, and procure winning products from the design competition

Resources

www.efficientpowersupplies.org

EPRI-PEAC and Ecos jointly developed and maintain this Web site as a global forum for sharing information about active mode power supply efficiency. All reports, draft and final test procedures, test data, and design competition details are housed here for easy access.

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